



memo

DATE: December 7, 1987

FROM: Fred Wucherpfennig *[Signature]*

TO: Steve Points
Henry Tetzlaff
Helmut Ullrich

cc: Dan Peterson
Mike Roy

SUBJECT: EVALUATION OF UNIQUE MOBILITY MODIFIED GR 3000

On December 2nd through 4th, Dan, Steve, Helmut and I were in Colorado to perform the initial evaluation of the GR 3000, which Unique has modified to have all electric drive. The machine is powered by the standard Kohler 16 HP air cooled engine driving an alternator via a belt. The alternator output is rectified to DC and regulated to approximately 42V max. The alternator output is coupled in parallel to a series of batteries which provide power at anytime the alternator does not have the required capacity. This electrical power runs to the three reel motors and two wheel motors through individual controllers. The five motors are of identical design with the wheel motors running through a double planetary gearset to achieve the desired wheel rational speed.

The initial evaluation was just driving around the parking lot at Unique's location. The traction drive had a reasonably good feel. It is somewhat "softer" than the feel of the standard hydraulic drive machine, in that it is possible by stepping on the traction pedal very quickly to spin the tires on the standard GR 3000. This is not possible on the electric drive machine due to slower acceleration caused by lower torque output due to current limiting on the motor circuits. The overall appearance of the machine was quite good, with well thought out and well executed mechanical design for a feasibility type prototype. The box containing the reserve batteries and the motor controllers is very large and somewhat unsightly, which would present quite a challenge to execute in a stylish way for a production product.

The second evaluation was at Highland Hills Municipal Golf Course in Greeley. John Beattie joined us for this evaluation since we also had the prototype which he built, along for comparison. The Unique prototype drove well on the level ground. As soon as any grade was encountered, the traction speed slowed down significantly. The machine would not even climb a 10% slope. The amount of torque delivered by the traction motors was not sufficient to climb the hill. The amount of power taken from the engine was never enough to even pull down the engine on the governor droop.

Exhibit C

When on a flat green, the speed was constant enough to attempt some mowing. After tweaking the traction drive speed to obtain the correct groundspeed (as compared to a standard GM 300), the cutting units obviously ran at different speeds from each other. By measuring clips, we estimated a 40% variation from fastest to slowest. It appeared that even the fastest reel was running too slow (the clip was too long). We were assured by Unique that this was occurring because a speed adjustment was not set correctly, and it could be set so all three reels ran at the same speed. It appeared that the reels took approximately two to three seconds to achieve full speed compared to a requirement of about one second. The lift and lower of the cutting units appeared to take approximately twice as long as on the GM 300.

The current limit on the wheel drive controllers was turned up in an attempt to obtain more traction torque. After a short time of operation, one of the controllers quit working, apparently due to an overstressed power MOSFET. Evaluation was necessarily discontinued at that point.

We met with Unique and discussed the technical issues uncovered:

- Lack of required traction torque.
- Wide variation of traction speed as load varies.
- Poor reliability of MOSFETS as used in current design.
- Incorrect reel speeds.
- Slow reel start up.
- Slow lift and lower of cutting units.

Unique will put together a proposal recommending what action is necessary to rectify the known problems and an estimate of timing and cost involved to do so.

The prototype will remain at Unique for the present time because it was judged to be totally unuseable in the current configuration. Unique will upgrade the machine to output the specified amount of torque, correct the reel speed problems, and correct the cutting unit lift/lower rate. I expect that Unique will propose that TORO fund the work to rectify the other problems uncovered, since they have (in their opinion) pretty much fulfilled the original commitment. It seems that the amount of torque specified in the agreement is about half of the required torque. We will need to negotiate with them about that once they have completed the original agreement.

I do think there is opportunity for the electric drive to function as needed, however, the complexity of the system, and therefore the cost, will need to be increased. I think the proposition is still very high risk at this point.

If you need any more details, feel free to call.

FW/kr

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